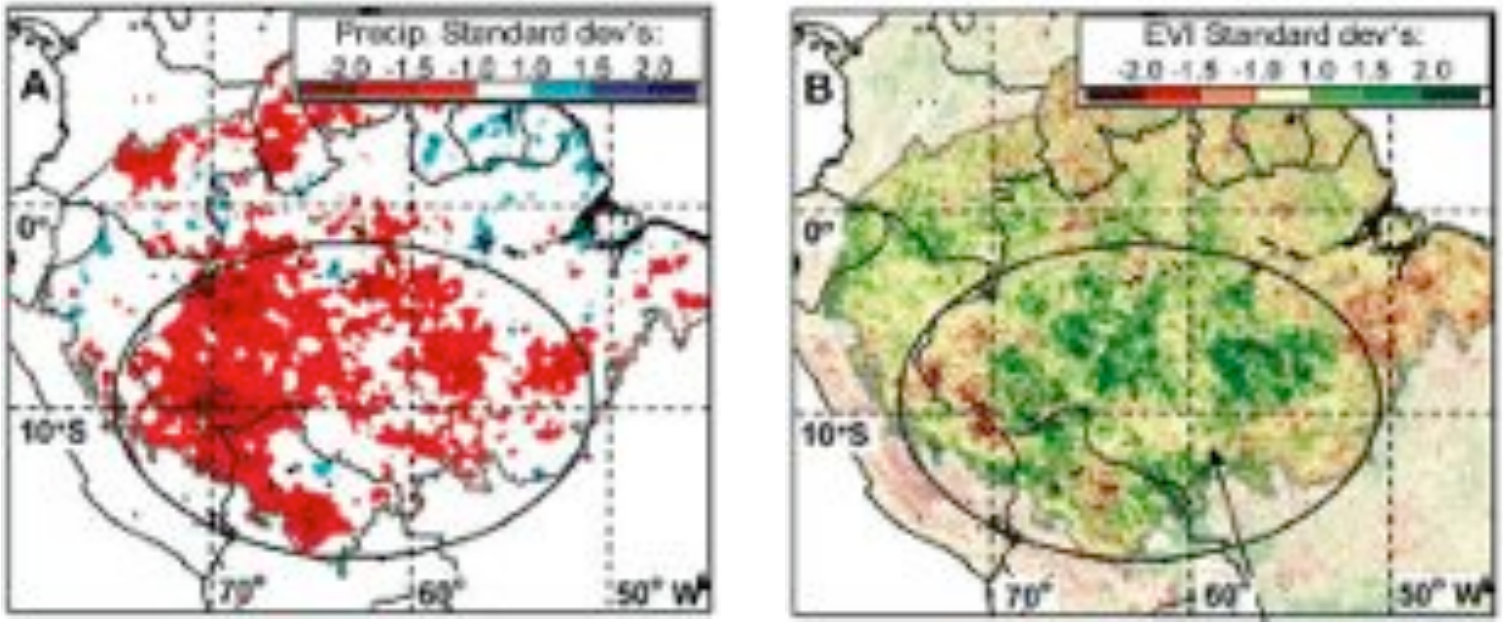
Amazon Forests Green-Up During 2005 Drought

Saleska, Didan, Huete and da Rocha
Science, Volume 318, Page 613, 2007

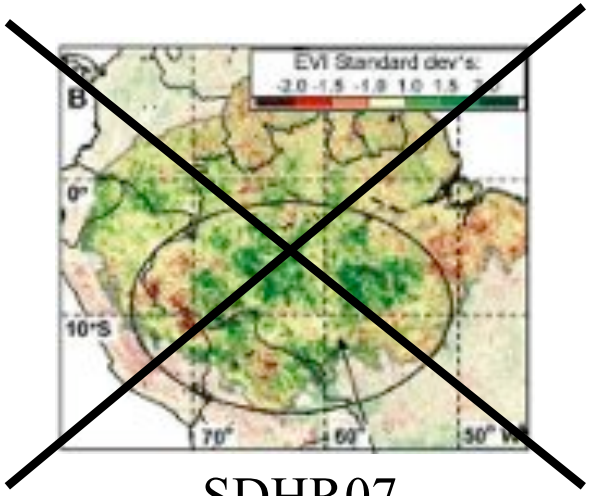


Std. Anom = (Q3_2005_data minus baseline_Q3_average) divided by (baseline_Q3_std_dev)
Baseline period 2005 to 2006 excluding 2005

"Drought intensity peaked during dry season onset (July to September), primarily in southwest and central Amazônia"

"The observations of intact forest canopy "greenness" in the affection areas, however, are dominated by a significant increase … not a decline"

We argue that



SDHR07

Amazon Forests Did Not Green-Up During 2005 Drought

WHY IS ALL THIS IMPORTANT?

- Drought sensitivity of these forests unknown
- Example: Phillips et al. (2009) report these forests changing from a sink to a source in 2005
- The forests hold a lot of carbon (100 billion tons of C)
- If they should dry out due to climate change, that will release a lot of carbon to the atmosphere (before we have a chance to cut them down and release the same carbon to the atmosphere)

Amazon Forests Did Not Green-Up During 2005 Drought

(accepted for publication in GRL)

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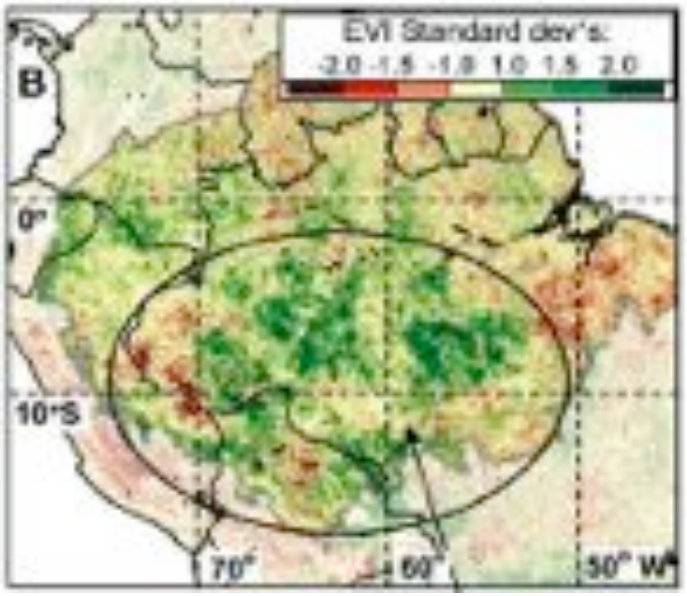
Question-01

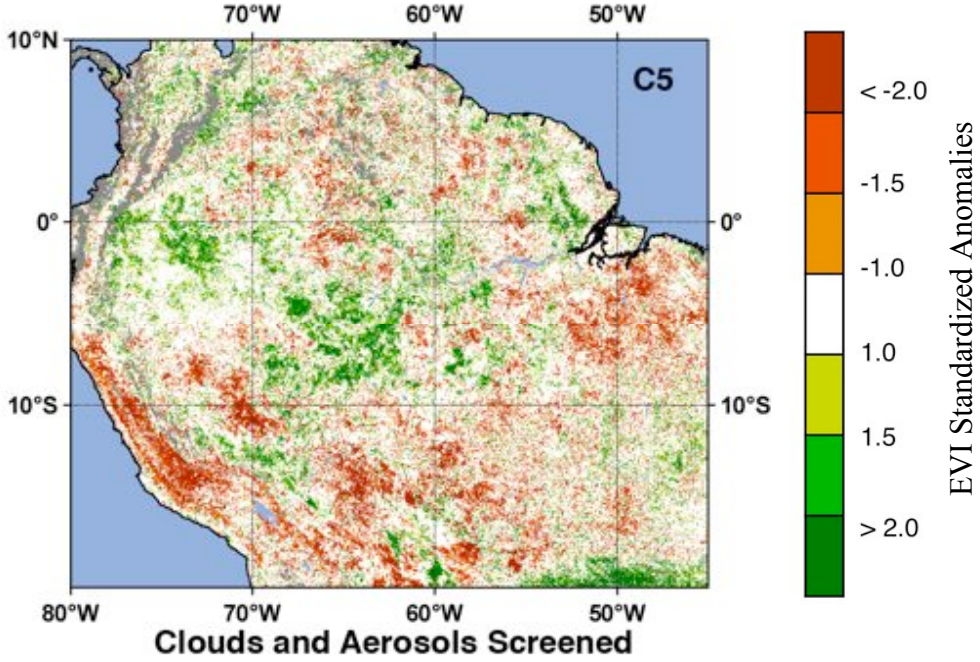
Are the results published in SDHR07 reproducible with Terra MODIS C5 EVI data?

C5: Irreproducibility

Collection 4 (SDHR07)



Collection 5



- **Identical analysis, only difference is the collection**
- **In the drought-impacted area, intact forests show in C5 -**
  37.0% Less Greening, 57.6% More Browning, 13.5% More No-Change

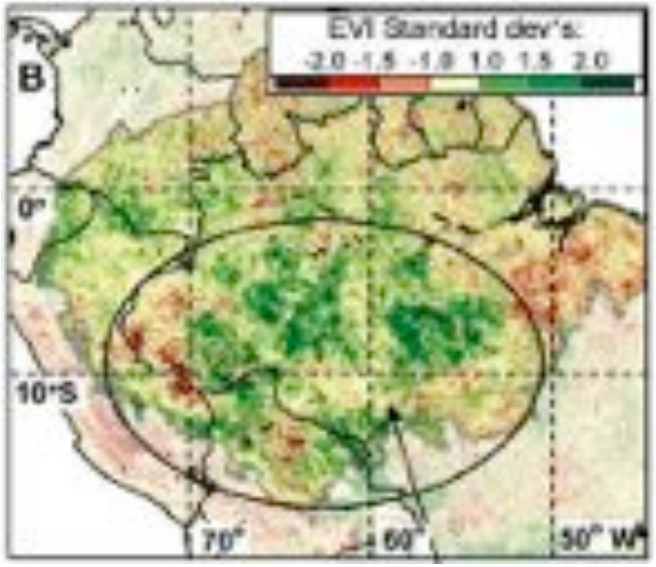
Answer: SDHR07 Results Are Irreproducible with C5 EVI

Question-02

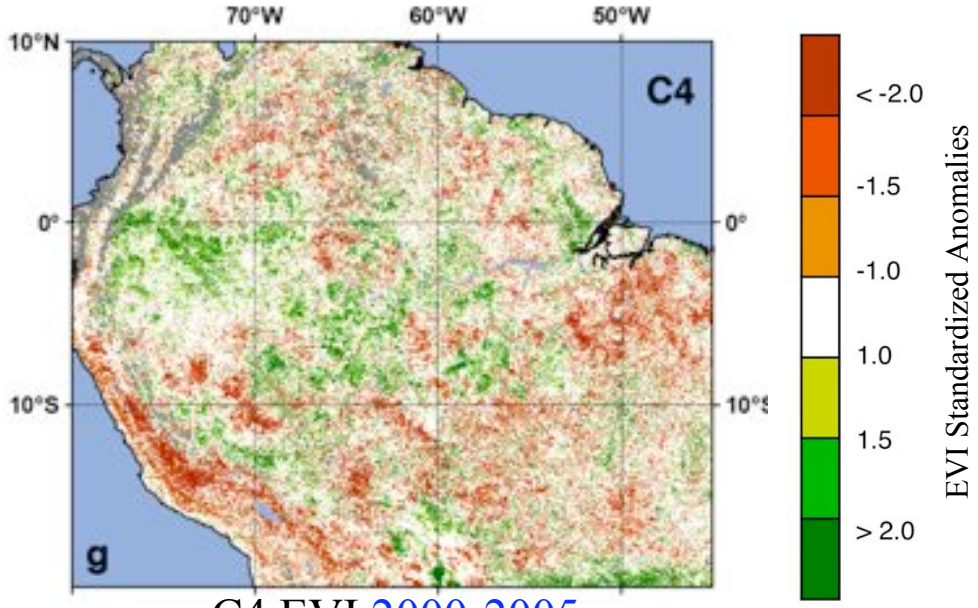
Are the results published in SDHR07 reproducible with the available Terra MODIS C4 EVI data?

- **C4 data have been decommissioned and deleted**
- **SDHR07 gave us 2000-2005 C4 EVI**
- **Data for 2006 not available**
- **C4 quality flags not available**

C4: Irreproducibility



C4 EVI 2000-2006 (SDHR07)
C4 Ranks?



C4 EVI 2000-2005
C5 Quality Flags

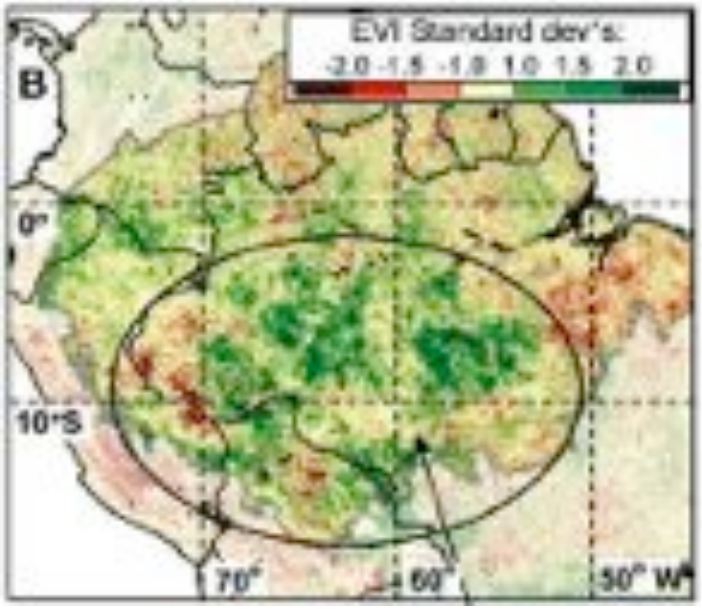
- **Identical analysis, except for the noted differences**
- **In the drought-impacted area, intact forests show -**
  36.0 % Less Greening, 65.1 % More Browning, 11.6 % More No-Change

Answer: SDHR07 Results Are Irreproducible with available C4 EVI data

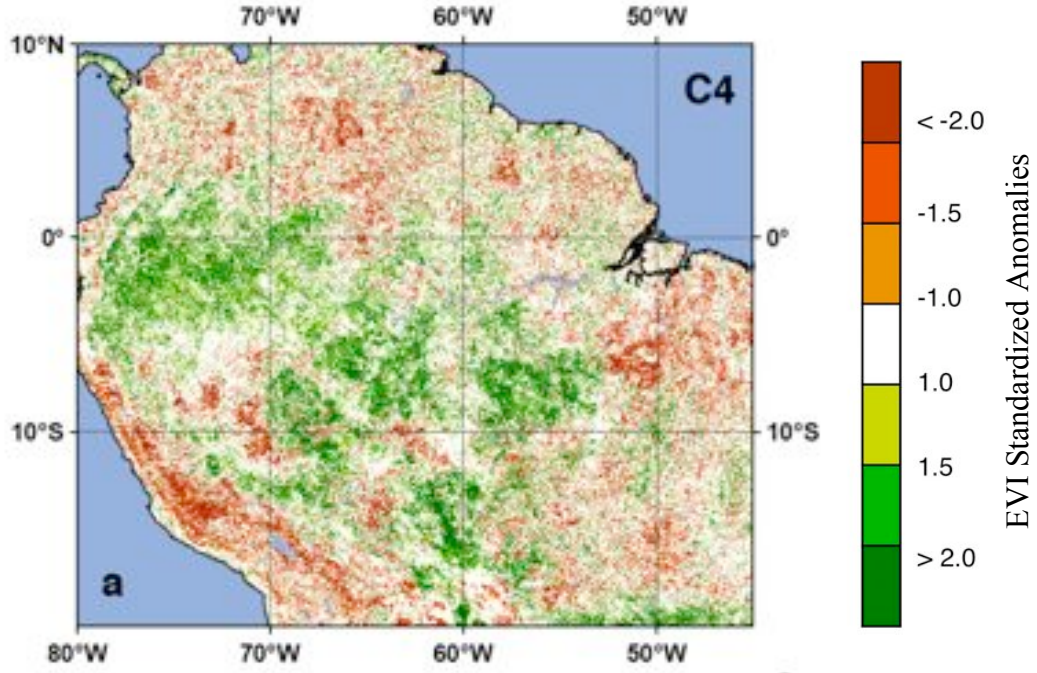
Question-03

Did SDHR07 effectively screen for cloud and aerosol contaminated EVI?

C4: Pixel Screening-01



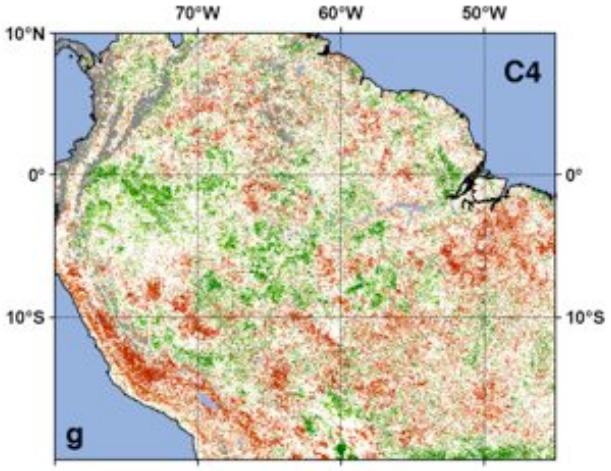
C4 EVI 2000-2006 (SDHR07)
C4 Ranks?



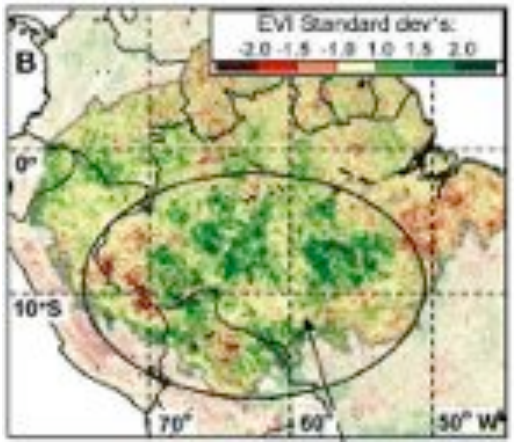
C4 EVI 2000-2005
No Screening

- **In the drought-impacted area, intact forests show negligible differences**
- **SDHR07 claim to have screened for cloud and aerosol corrupted pixels**
- **What is going on?**

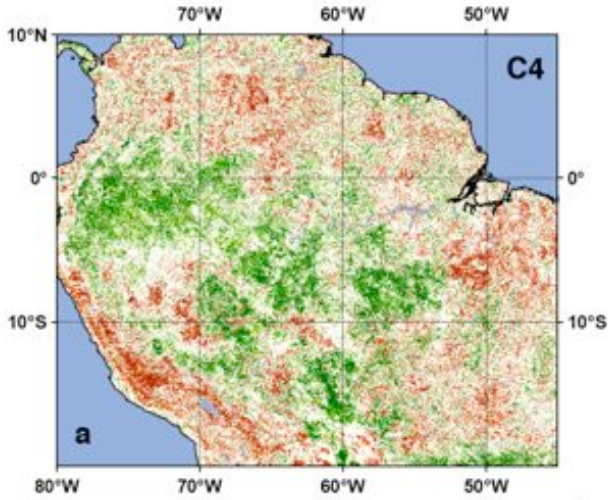
C4: Pixel Screening-02



C4 EVI 2000-2005
C5 Quality Flags



C4 EVI 2000-2006 (SDHR07)
C4 Ranks?



C4 EVI 2000-2005
No Screening

- **SDHR07 rank screening effective**
  - C4 QA flags unlike C5 QA flags
  - C4 QA flags useless
  - No need to even screen
- **SDHR07 rank screening ineffective**
  - C4 QA flags like C5 QA flags
  - SDHR07 thought (& still think?) they screened, but in fact did not

Answer: **Need C4 EVI and QA Flags**
SDHR07 should tell us what is "rank screening"

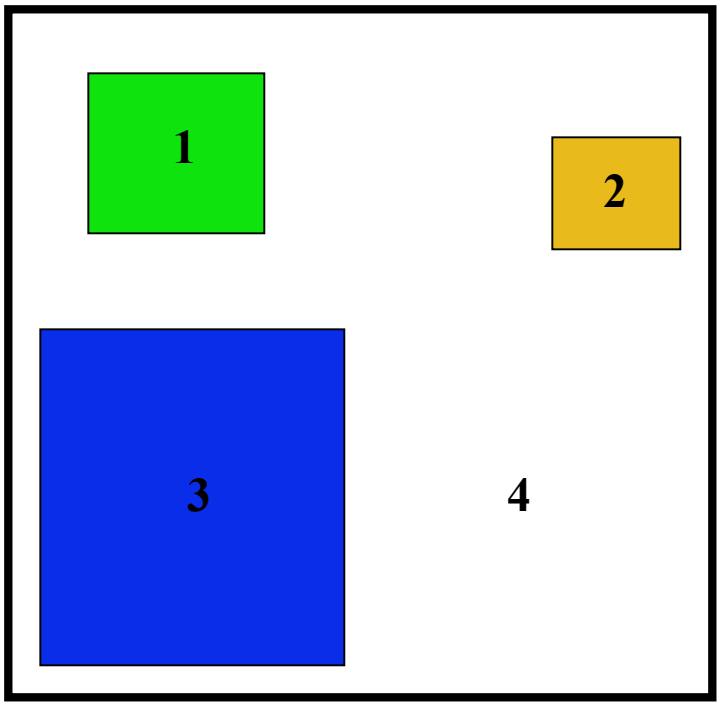
Irreproducibility: Summary

- **SDHR07 results are irreproducible with C5 EVI**
- **SDHR07 results are irreproducible with available C4 EVI data**
- **Need C4 EVI and QA Flags to ascertain if SDHR07 screened effectively for cloud and aerosol contaminated EVI data**

Question-04

How extensive was Amazon-greening during 2005 drought?

Objective Counting-01



Intact Forest Area Within the Drought =
Green+Brown+Blue+White = 2.2 mil km^2

(1) Green: Forests showing greening = 12.4%
(2) Brown: Forests showing browning = 5.6%
(3) Blue: Forests showing no-changes = 21.8%
(4) White: Forests for which valid EVI data is lacking = 60.2%

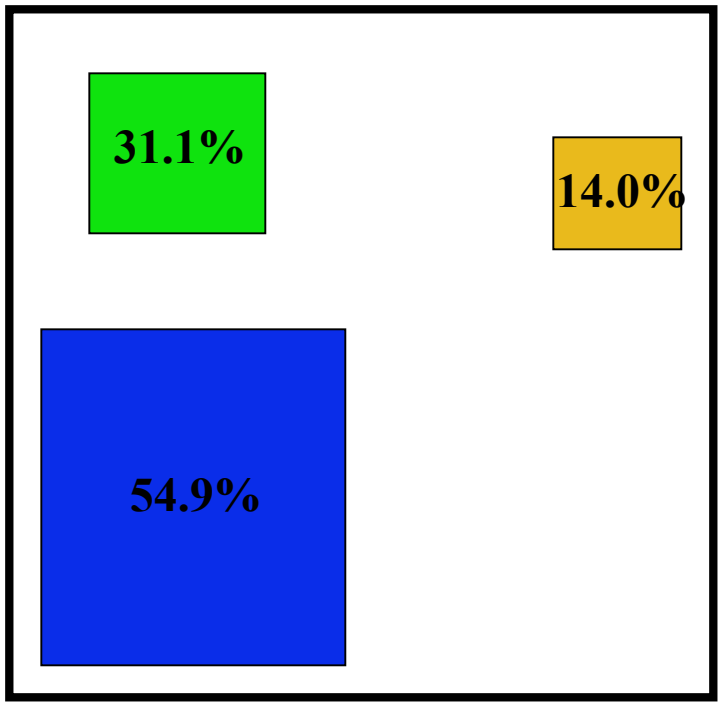
Based on C5 EVI data for 2000 to 2006 (42 values per pixel)

Std. Anom = (Q3_2005_data minus baseline_Q3_average)
divided by (baseline_Q3_std_dev)

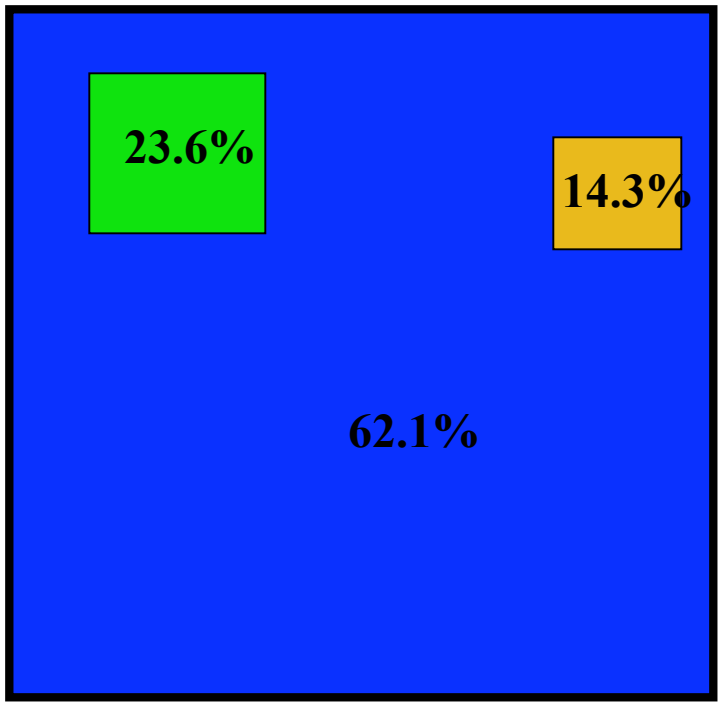
- Less than 13% of the forest area impacted by the drought shows greening
- More than 60% of the forest area within the drought region lacks valid EVI data

Answer: The conclusion "Amazon forests green-up during 2005 drought" is not warranted.

Subjective Counting-01



Our Numbers

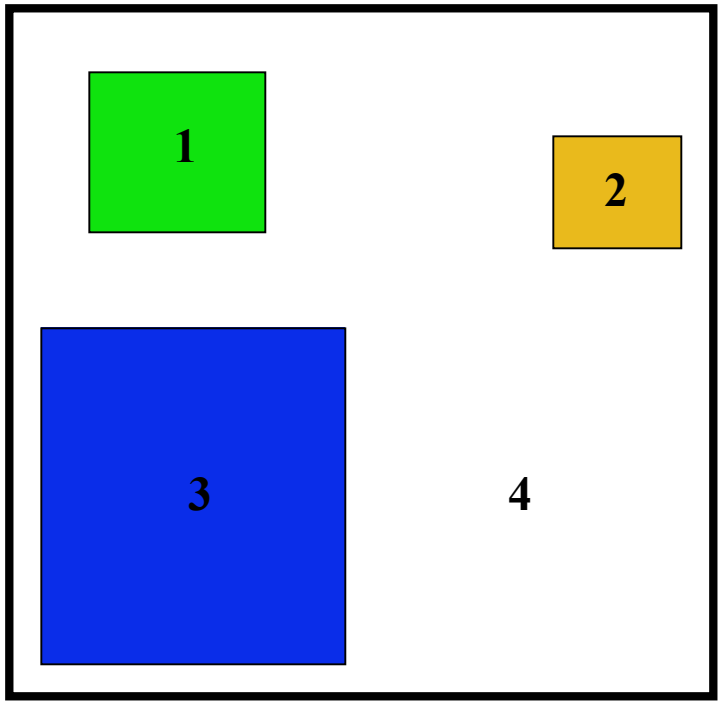


SDHR07

- 24-31% of the forest area shows greening
- 69-76% of the forest area shows browning or no changes
- Based on C5 EVI data for 2000 to 2006

Answer: **No large-scale greening of Amazon forests during 2005 drought**

Subjective Counting-02



(1) Green: Forests showing greening = 60.3%
(2) Brown: Forests showing browning = 39.6%

Intact Forest Area Within the Drought Exhibiting Greening or Browning = Green+Brown

Based on C5 EVI data for 2000 to 2006

- **One can manipulate the fractions, but the area of greening will not change!**

Green-up Summary

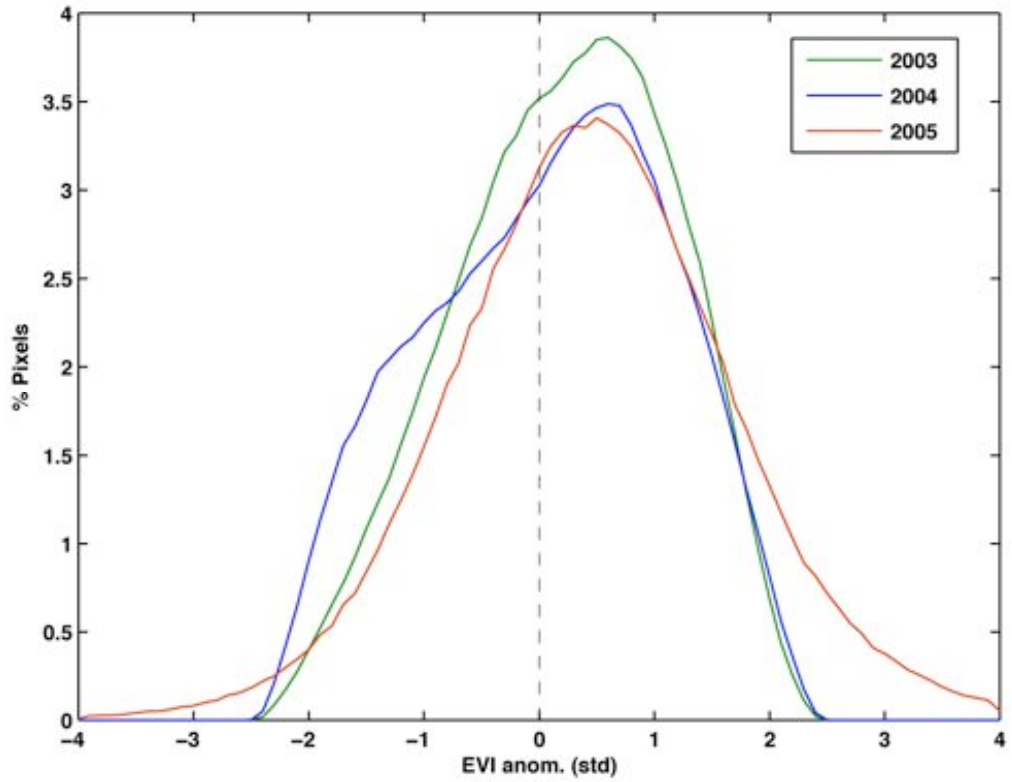
- **No large-scale greening of Amazon forests during 2005 drought**

- **SDHR07 are counting their chickens wrong**

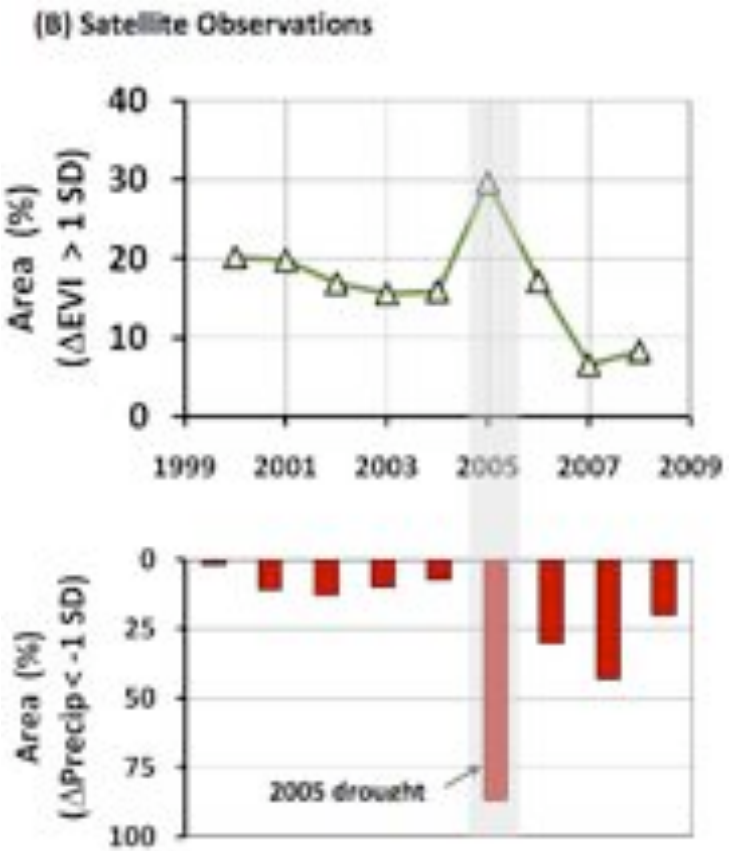
Myth-01

Year 2005 changes (more greening than browning) are unique because of drought

Year 2005 Changes Unique?



Year	Greening (%)	Browning (%)	No Change (%)	Valid Pixels (%)
2000	5.19	6.13	23.75	35.09
2001	5.15	5.68	24.24	35.09
2002	5.08	6.05	23.95	35.09
2003	**8.05**	**4.12**	**22.90**	**35.09**
2004	**7.56**	**6.72**	**20.80**	**35.09**
2005	**10.80**	**3.89**	**18.98**	**33.68**
2006	4.95	3.86	26.27	35.09
2007	4.76	6.43	23.88	35.09
2008	3.10	6.57	25.40	35.09



Saleska et al. (2009) Response to our Comment

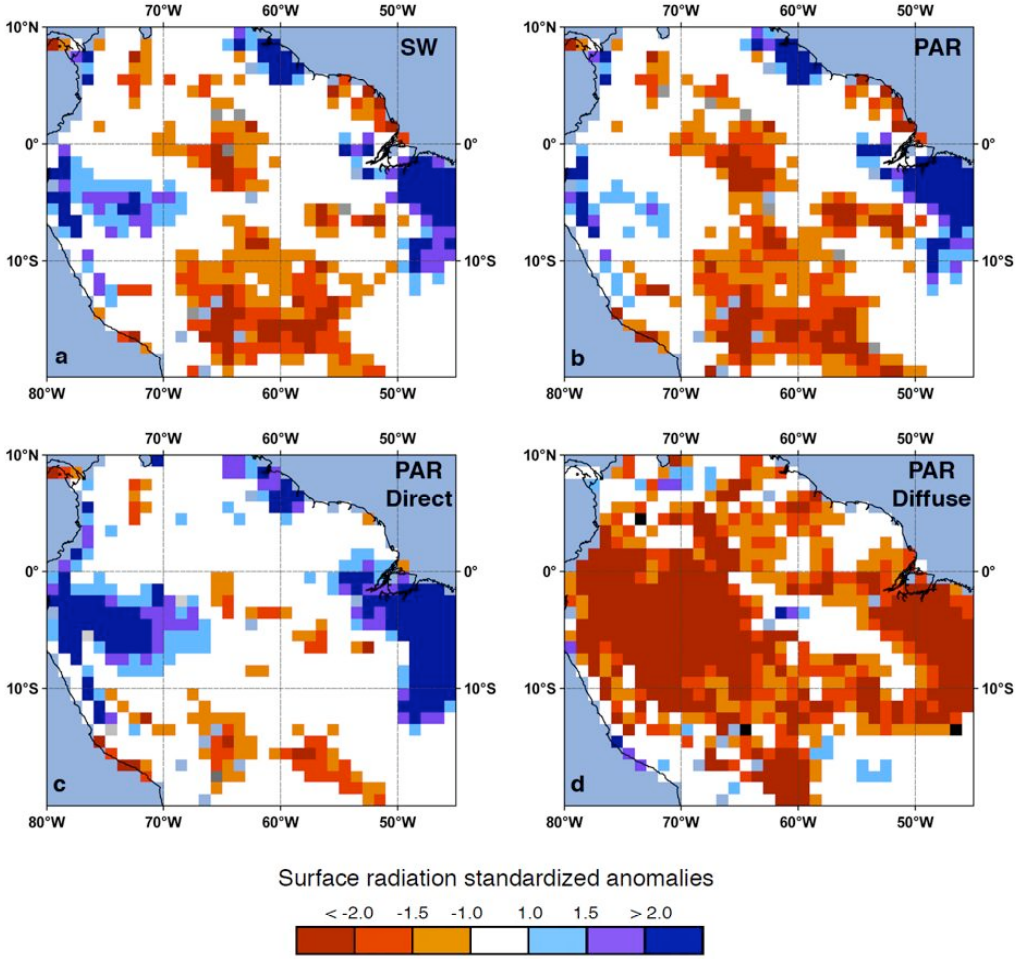
Similar changes are seen in non-drought years (2003 and 2004, for example)

Myth-02

Dry season drought in 2005 = fewer clouds = more sunshine = forests green-up because they are not water-limited as they have deep roots etc.

SDHR07 write “Increased greenness is inconsistent with expectation if trees are limited by water but follows from increased availability of sunlight (due to decreased cloudiness) when water is not limiting …”

More Sunshine?



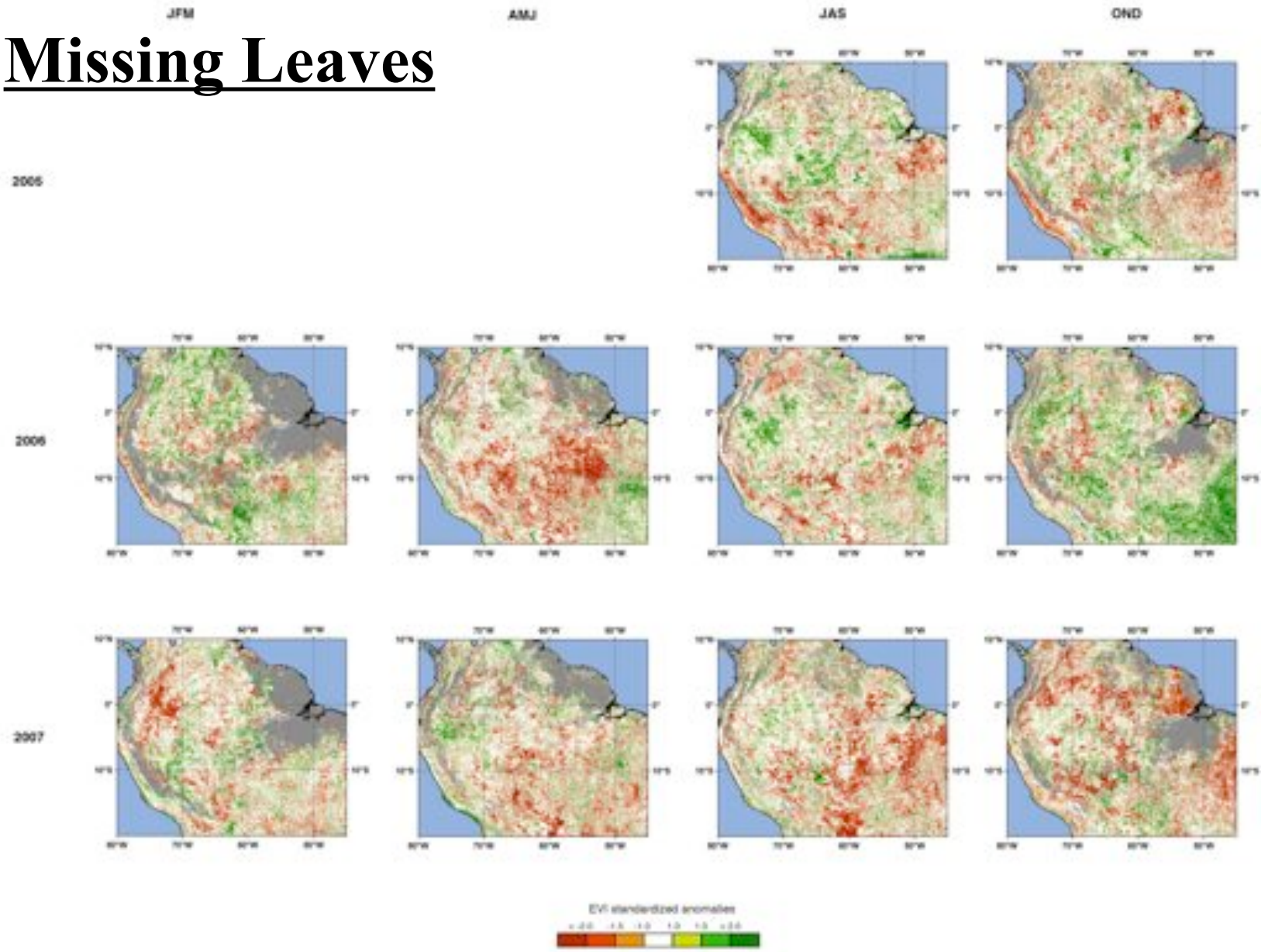
- CERES Data (2000-2005)
- Surface SW radiation declined over 35% of forest area
- Surface PAR declined over 47.5% of forest area
- Diffuse PAR declined over 78.5% of forest area

There is no evidence of enhanced surface sunlight levels during the drought of 2005

Myth-03

If the forests greened-up in Q3 of 2005,
what happened to all those leaves?

Missing Leaves



Average leaf age in sunlit canopies: 1.6 to 2.5 years

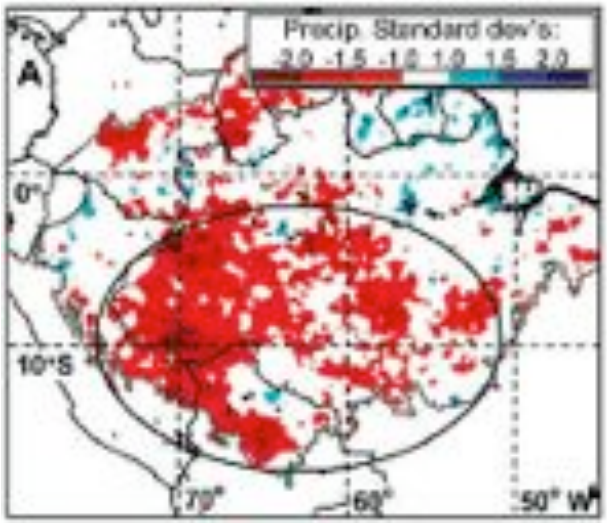
(Reich et al., Leaf demography and phenology in Amazonian rain forest: A census of 40 000 leaves of 23 tree species, Ecological monographs vol. 74, no1, pp. 3-23, 2004)

Myth-04

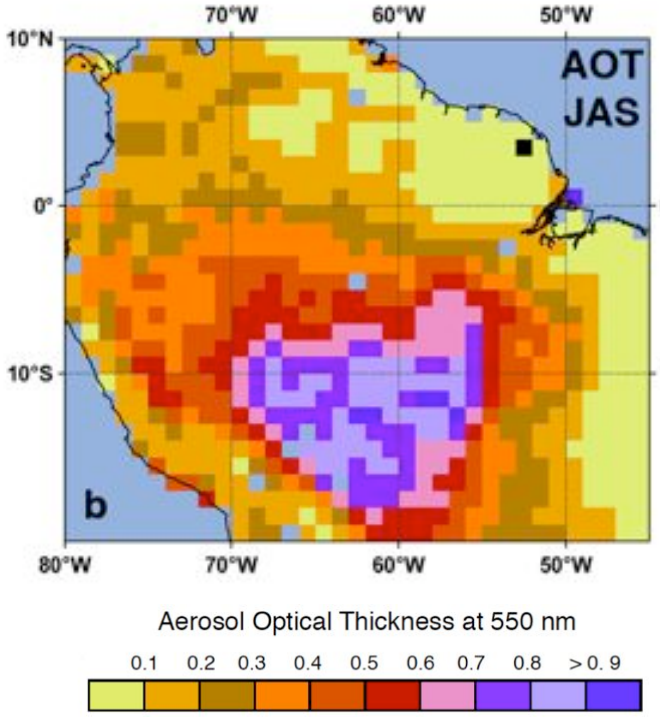
Aerosols were not important

Dry season = biomass burning season in the Amazon

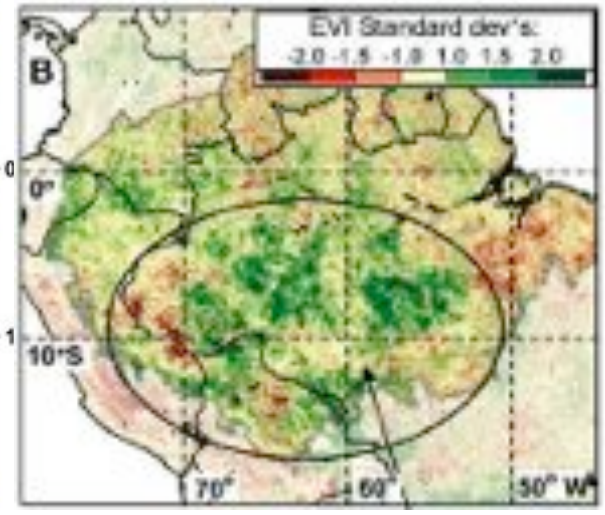
MODIS C5 AOT



SDHR07



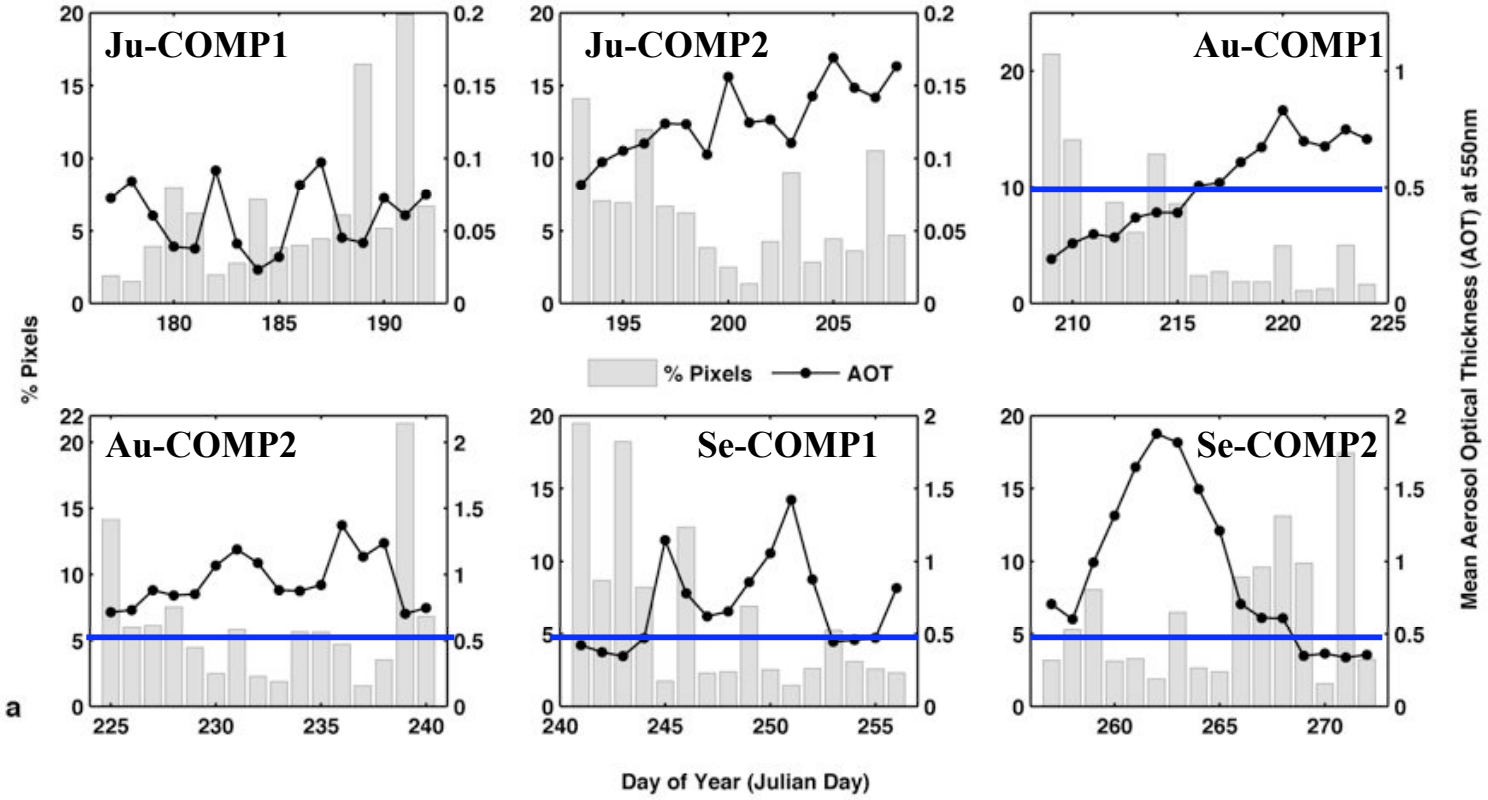
MODIS C5 AOT



SDHR07

Forests within the drought region were under a perpetual haze (AOT > 0.5)

Daily AOT



From about DOY 216 (2005), forests within the drought region were under a perpetual haze (AOT > 0.5), with the exception of a few days

Anomalous AOT

MODIS AOT

2005 AOT

2006 AOT

2005-2006

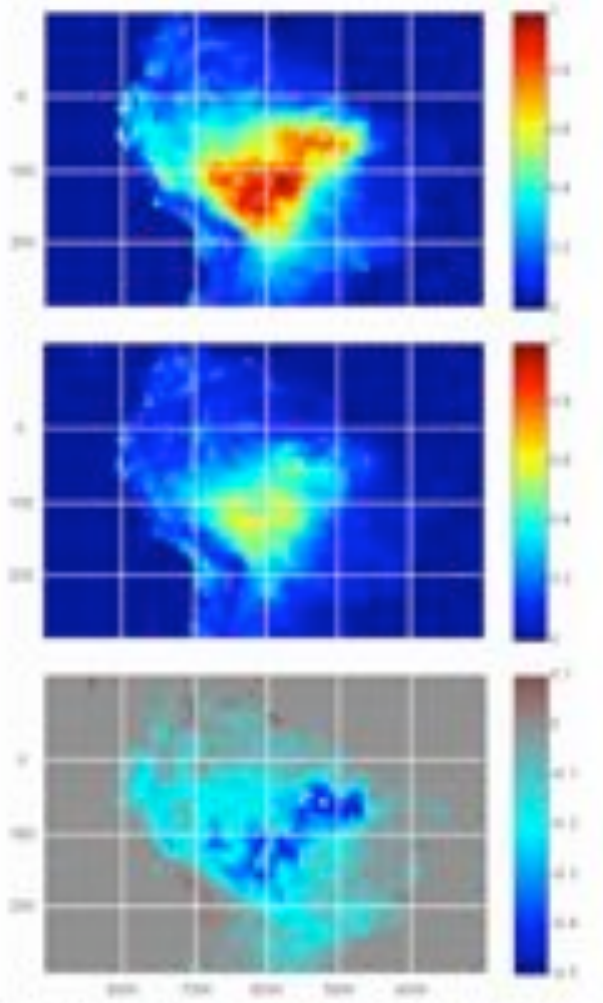
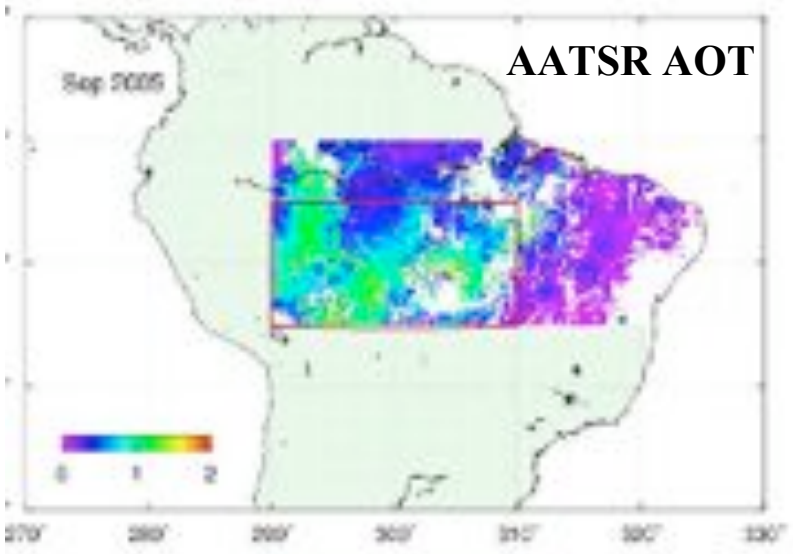


Figure 3. (top) Mean aerosol optical depth for the dry season of 2005. (middle) Mean aerosol optical depth for the dry season of 2006. (bottom) Difference in AOD between the biomass burning season of 2006 and that of 2005 for each 1 degree square. The brightening blue color indicates increasing negative difference showing that AOD in 2006 was dramatically lower than it was in 2005.

Koren, Remer and Longo, GRL, doi:10.1029/2007GL031530, 2007

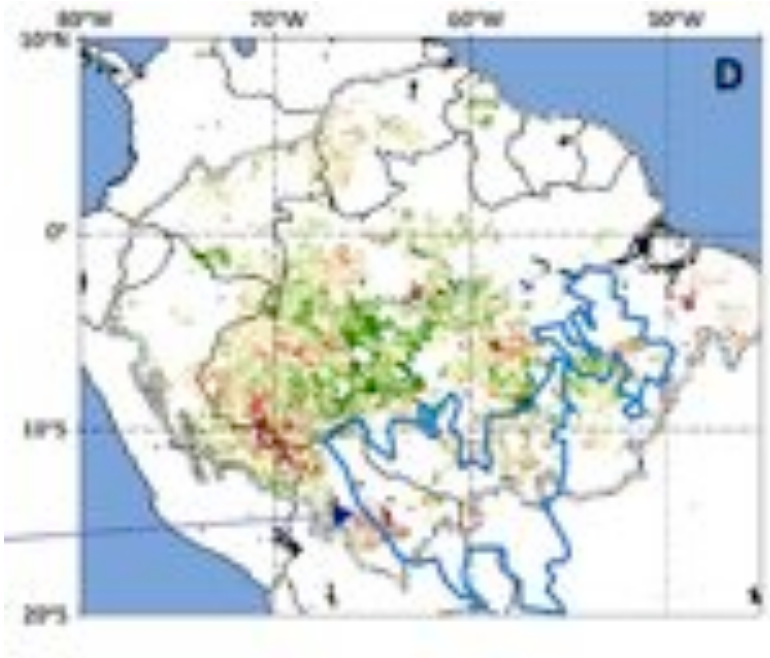


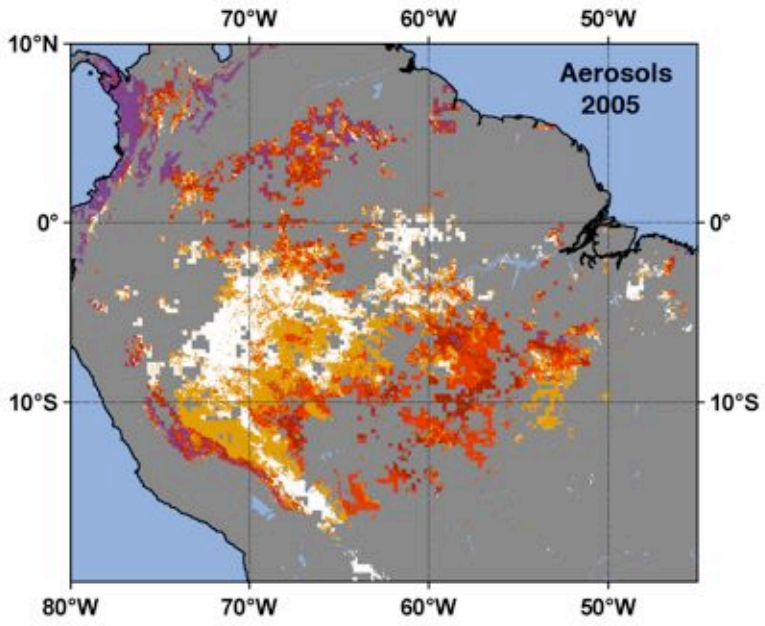
Bevan et al., JGR, doi:10.1029/2008JD011112, 2009

During 2005 the annual cumulative number of hot pixels in Amazonia increased 33% in relation to the 1999-2005 mean (Aragao et al., doi:10.1029/2006GL028946, 2007).

Exceptionally high AOT in 2005 due to drought and biomass burning

C5 High Aerosol QA Flags

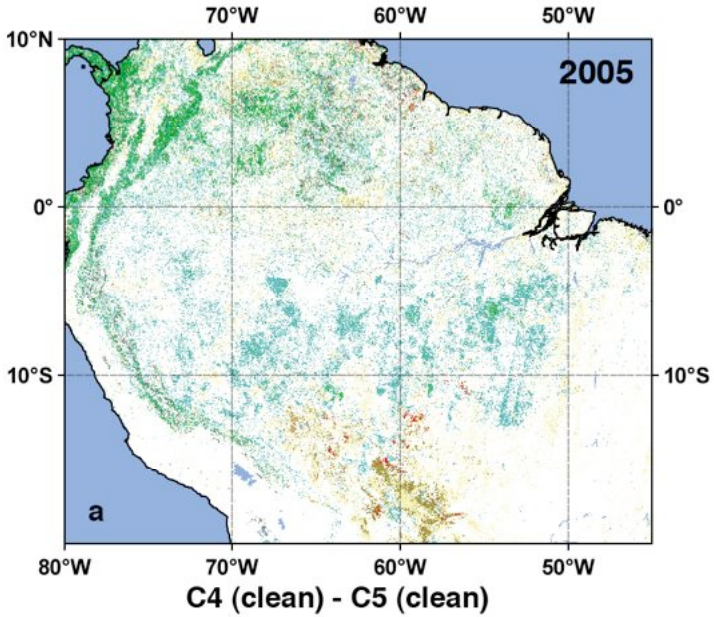


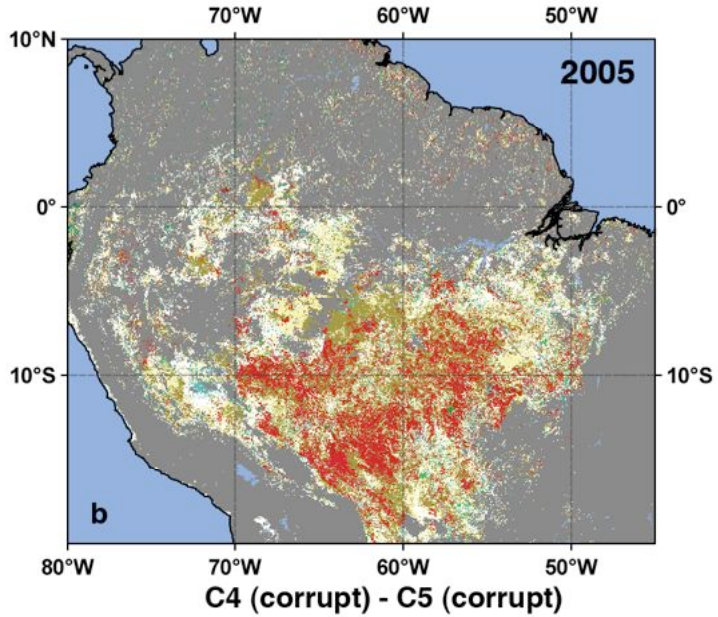


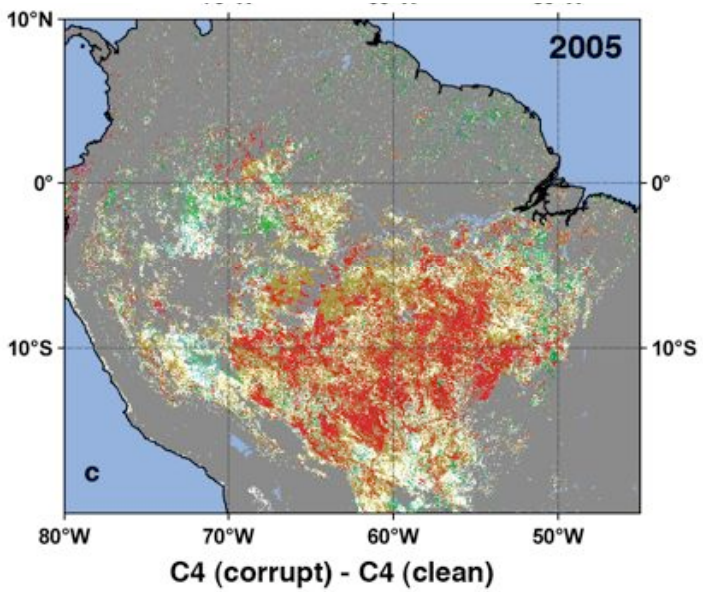
Saleska et al. response to our comment:
"In other words, high aerosols were, for the most part, not in the drought area we analyzed, and therefore could not have much affected the outcome of our analysis."

QA Flags Indicate High Aerosol Amount in the Drought Area

EVI Differences

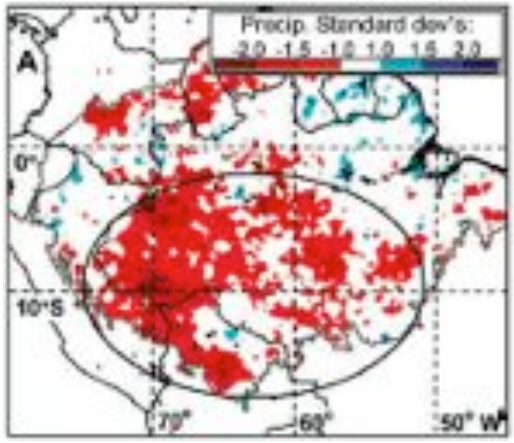




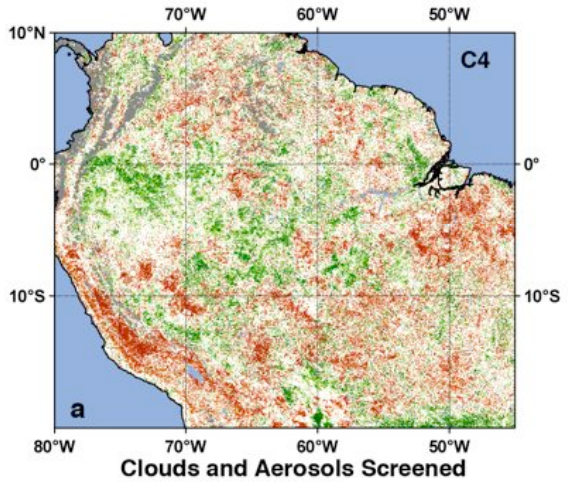


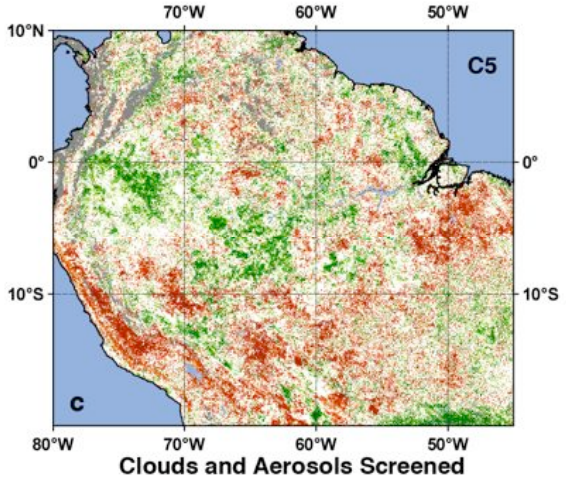
- C4 Corrupt pixel EVI values high
- SDHR07 greening is an artifact of including atmosphere-contaminated pixels in their analysis (knowingly or unknowingly).

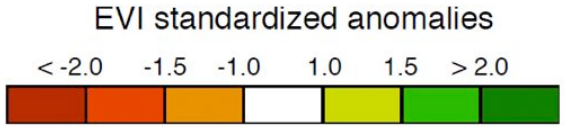
Screen Aerosols & Clouds

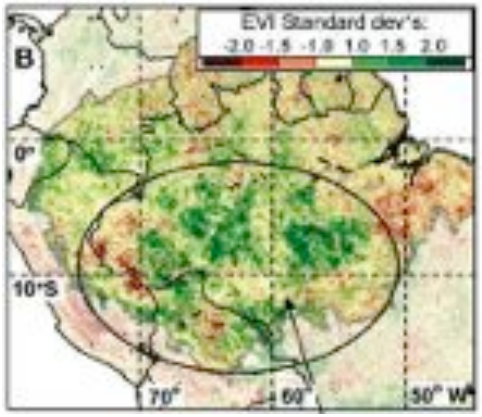


SDHR07









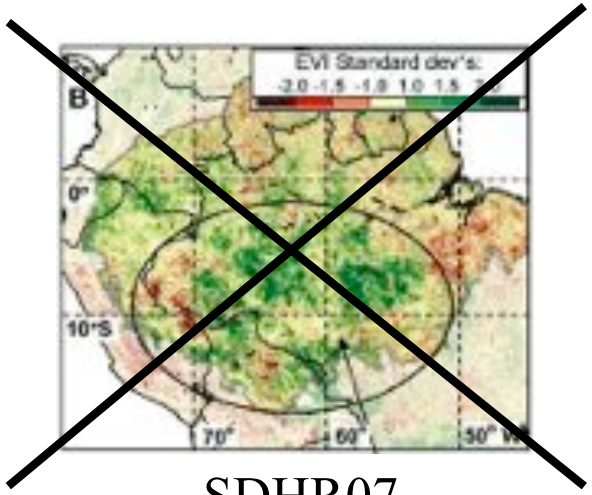
SDHR07

If screened for clouds and aerosols using C5 quality flags,

- **both C4 and C5 yield similar patterns**
- **these patterns do not resemble SDHR07**
- **these patterns do not show greening**

even following the flawed method of SDHR07.

Conclusion



SDHR07

Amazon Forests Did Not Green-Up During 2005 Drought